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**Patentanmeldung Nr. | Patent application No. | Demande de brevet n°**

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Method and ballast for driving a high pressure gas discharge lamp

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# Method and ballast for driving a high pressure gas discharge lamp

The invention relates to a method for driving a high pressure gas discharge lamp during its steady state operation, wherein a steady state current signal is sent through the lamp for maintaining an arc in the lamp, comprising the step of comparing the lamp voltage response to a current step in said current signal with reference parameters; and in response to said comparison at least on of the steps comprising: stopping the power supply to the lamp, generating a signal indicating the end-of-life status of the lamp, generating a signal representing the lamp type, changing the steady state current intensity through the lamp, changing the steady state waveform of the current signal through the lamp.

Such a method was disclosed by K. Günther of OSRAM GmbH during the Seventh International Symposium on the Science & Technology of Light Sources, held from 27th to 31st August 1995 in Kyoto, Japan, and is described on pages 93 to 100 of the Symposium Proceedings, published in 1995 by The Illuminating Engineering Institute of Japan. The teachings of this document are incorporated herein by reference, in particular the teaching concerning the correlation between the electrical conductivity of the lamp and its photometric properties, as well as the teaching concerning response signal processing and analysis.

In said Symposium Proceedings it is suggested to detect the radiation properties of the lamp by analysing the electrical conductivity response in a pulsed mode operation ballast, or in the case of a metal halide lamp by applying a power step to the lamp and measure the decay or rise time of the conductivity response. The first alternative is limited in its application to said pulsed operation mode, whereas the second alternative influences the operation of the lamp such that the intensity of the lamp will increase or decrease.

The object of the invention is to analyse the lamp conductivity response to a power step in such a way that the method is applicable to a broad range of operation modes,

while the intensity or colour temperature of the lamp remains unchanged or alternatively can be changed in a controlled manner.

According to the invention said power step is obtained by sending a current pulse which is superimposed on the steady state current signal through the lamp.

Said steady state current signal thereby may have any form, for instance a perfect sinusoidal form or a pure DC. Furthermore the duration of the superimposed pulse may be shorter than the decay or rise time of the voltage response of a current step in the aforementioned known alternative would be, and rather than measuring the decay or rise time of the voltage response the form of response may be analysed.

In a first preferred embodiment the duration of said pulse is preferably shorter than the duration of the cyclic alternating pulse of the steady state current signal. The superimposed pulse can also be a negative pulse, or a "dip" in the signal.

In a second preferred embodiment, for instance in a high frequency operation mode, the duration of said pulse is a multitude of the duration of the cyclic alternating pulse of the steady state current signal, wherein preferably the pulse is comprised of a temporarily intensified amplitude of said cyclic alternating pulse of the steady state current signal.

Preferably the step of comparing the voltage response comprises measuring the decay time of the voltage and comparing it to a reference decay time, or analysing the shape of the response signal and comparing it to reference values.

In a further preferred embodiment the step of changing the steady state waveform comprises the step of superimposing a recurring power pulse on said steady state waveform, which is for instance a square or sinusoidal wave, for changing the colour temperature of the lamp. In this manner the waveform is changed to a more complex recurring form which has an effect on the colour temperature of the lamp without necessarily having much influence on the intensity of the lamp.

The invention further relates to a ballast for driving a high pressure gas discharge lamp comprising power supply means for sending a steady state current signal through the lamp for maintaining an arc in the lamp, response comparing means for comparing the lamp voltage response to a current step in said current signal with reference parameters; and responding means for stopping the power supply to the lamp, generating a signal indicating the end-of-life status of the lamp, generating a signal indicating the lamp type, changing the steady state current intensity through the lamp, and/or changing the steady state waveform of the current signal through the lamp in response to said comparison, wherein said ballast further comprises pulse means for sending a current pulse which is

superimposed on said steady state current signal through the lamp for obtaining said current step. Means for implementing the aforementioned preferred method embodiments may be comprised in said ballast, whether separately or in combination.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a ballast and lamp configuration;

Fig. 2 shows an example of a steady state square waveform, a recurring pulse, the combined signal and its dynamic voltage response used in the method according to the invention; and

Fig. 3 shows a plot of various white HPS lamp examples of different age having different colour temperature values as indicated, plotted against their dynamic voltage response decay time (tau) as well as the lamp voltage(Vla).

With reference to Figure 1, an electronic ballast 10 is connected to a high pressure gas discharge lamp 11 which contains an arc tube 12 having electrodes 13, 14 sealed into opposing ends of arc tube 12. The first electrode 13 is connected to one terminal of ballast 10, and the remaining electrode 14 is connected to the remaining terminal of ballast 10.

In particular White HPS lamps suffer from loss of sodium from the amalgam fill in the arc tube due to corrosion or diffusion during their life, which leads to a lower colour temperature of the lamp. It was one object of the invention to detect this decreased colour temperature in order to determine the end-of-life of the lamp 11 if the colour temperature is below an acceptable limit, without the need for optical measuring instruments such as photo diodes.

Therefore according to Figure 2 a short (1.4 ms wide) current power pulse (G2) is superimposed on its steady state low frequency (90 Hz) square wave current signal (G1) of an electronic ballast operating 100 W white HPS lamps, resulting in a combined current signal (I lamp). Then the dynamic response of the lamp voltage (V lamp) is detected by the electronic circuit of the ballast 10 and a characteristic decay or rise time (tau) can be determined. The decay time will in general vary in the range between about 1 μs and about 1.5ms.

It appears from Figure 3 that the response time, in particular the decay or rise time (tau) as a reaction to the applied power pulse for lamps with sodium loss (having a lower colour temperature) appear to be longer.

From Figure 3 it also appears that lamps 11 having a higher than normal colour temperature show a higher lamp voltage (Vla) related to a higher cold spot temperature of the lamp 11, which was already a known effect (see for instance European patent application EP-A-2281123). However lamps having a lower than average colour temperature equally show a higher lamp voltage (Vla), as can be seen in Figure 3. By an additional evaluation of the voltage response to a current pulse both types of deviation can be discriminated from each other.

In this example lamps complying with Vla > 105 V AND tau < 90 μs could be identified as having a too high colour temperature (> 2700 K), whereas lamps complying with tau > 90 μs could be identified as having a too low colour temperature (<2400 K).

In reaction to said identification the lamp 11 can be switched off. It is also possible, for example in a high aspect ration HID burner with a sodium cerium filling, to influence the colour temperature of the lamp 11 in reaction to and depending on the determined value of tau. This can be done for instance by adding a sufficiently high unidirectional direct current component to the alternating current and/or by superimposing a sufficiently high and wide recurring pulse to the current. Preferably such a recurring pulse which is applied for changing the colour temperature of the lamp is at the same time used to trigger the aforementioned voltage response.

It was found that both measures, adding a DC current component and current pulses, can influence the colour temperature of various types of high pressure gas discharge lamps 11, and that it can be applied in a controlled manner by using appropriate control circuitry in the ballast, which will however be apparent for the man skilled in the art.

White HPS lamps require some form of electronic control to keep the colour of the lamps between acceptable limits. A control algorithm used in practice is based on the existence of a correlation between the colour temperature of the lamp and the lamp voltage. This correlation is based on the fact that both the spectral distribution and the electrical characteristics are directly determined by the Na and Hg vapour pressures. This, however, holds only in case of a well-defined relation between these vapour pressures, which is only the case for a fixed amalgam composition. It fails in a situation where, for example, the amalgam composition changes as a result of Na corrosion or diffusion as the lamp ages. The impact of Na corrosion processes - even at the high Na vapour pressures in this type of lamps

- can suppressed sufficiently to obtain adequate lamp life. However, as the lamp ages, ultimately a point will be reached where the Na loss becomes significant. The consequence of this is that a colour control approach based on a sensing of the steady state electrical lamp characteristics has to fail. Fig. 1 illustrates the situation: for relatively new lamps (fixed amalgam composition with $x_{Na}$=0.74) there exists a unique relation between $T_C$ and $V_{la}$ (data are for 50 Hz operation). However, for old lamps (with severe loss of Na) we see a large drop in $T_C$ as compared to lamps with the same lamp voltage, resulting in an unacceptable yellowish appearance of the lamp.

A possibility for electronic control even in this case could be based on a method to sense the dynamic electrical properties as indicated by Günther. This might be accomplished by detecting the electrical response after subjecting the lamp to a short power pulse. In intelligent electronic ballast such information could be detected and used for correction of the lamp colour or, in a situation that the lamp is really way out of specification, to switch it off.

For the present investigation 100W White HPS lamps have been operated on a Low Frequency Square Wave type of electronic gear (LFSW frequency about 90Hz). The dynamic response was studied by superposition of a short current pulse (about 1.4 ms wide) on top of the LFSW wave (fig. 2). From the electrical response of the lamp voltage a decay time $\tau$ (1/e value) can be derived. Typical results for a group of "good" lamps (Table 1: 1-3) and for a group of old lamps (Table 1: 4-7) have been collected in Table 1. The decay time $\tau$ for these type of lamps appears to be of the order of 70 µsec, but in case of Na loss clearly longer $\tau$ values are found.

Table 1 Dynamic response results for various White HPS lamps

| Lamp # | $T_C$ (K) | $V_{la}$ (V) | $\tau$ (µsec) |
|---|---|---|---|
| 1 | 2583 | 95.5 | 72 |
| 2 | 2542 | 93.9 | 73 |
| 3 | 2874 | 110.9 | 71 |
| | | | |
| 4 | 2333 | 104.2 | 97 |
| 5 | 2156 | 106.2 | 114 |
| 6 | 2278 | 107.9 | 92 |
| 7 | 2254 | 104.8 | 97 |

From these data it can be concluded that a deterioration of the colour performance of White HPS lamps as a result of Na loss, can be detected by looking at the dynamical electrical response of the lamp.

CLAIMS:

1. Method for driving a high pressure gas discharge lamp (11) during its steady state operation, wherein a steady state current signal (G1) is sent through the lamp (11) for maintaining an arc in the lamp (11), comprising the step of comparing the lamp voltage response (Vlamp) to a current step in said current signal with reference parameters; and in response to said comparison at least one of the steps comprising: stopping the power supply to the lamp (11), generating a signal indicating the end-of -life status of the lamp (11), changing the steady state current intensity through the lamp (11), changing the steady state waveform of the current signal through the lamp (11), generating a signal indicating the lamp type, characterized in that said current step is obtained by sending a current pulse (G2) which is superimposed on said steady state current signal (G1) through the lamp (11).

2. Method according to claim 1, wherein the steady state current signal (G1) comprises an alternating current component.

3. Method according to claim 2, wherein the duration of said pulse (G2) is shorter than the duration of the cyclic alternating pulse or the half period of the AC current signal of the steady state current signal (G1).

4. Method according to claim 1, 2 or 3, wherein the superimposed pulse (G2) is a negative pulse.

5. Method according to claim 2, wherein the duration of said pulse (G2) is a multitude of the duration of the cyclic alternating pulse or half period of the AC current signal of the steady state power signal (G1), wherein preferably the pulse (G2) is comprised of a temporarily intensified amplitude of said cyclic alternating pulse of the steady state power signal (G1).

6. Method according to any of the previous claims 1 - 4, wherein the step of comparing the voltage response (Vlamp) comprises measuring the decay or rise time (tau) of the voltage and comparing it to a reference decay or rise time.

7. Method according to any of the previous claims 1 - 4, wherein the step of comparing the voltage response (Vlamp) comprises analysing the shape of the response signal and comparing it to reference values.

8. Method according to any of the previous claims 1 - 4, wherein the step of changing the steady state waveform (G1) comprises the step of superimposing a recurring current pulse (G2) on said steady state waveform for changing the colour temperature of the lamp (11).

9. Ballast (10) for driving a high pressure gas discharge lamp (11) comprising power supply means for sending a steady state current signal (G1) through the lamp (11) for maintaining an arc in the lamp (11), response comparing means for comparing the lamp voltage response (Vlamp) to a current step in said current signal with reference parameters; and responding means for stopping the power supply to the lamp (11), generating a signal indicating the end-of-life status of the lamp (11), generating a signal indicating the lamp type, changing the steady state current intensity through the lamp (11), and/or changing the steady state waveform of the current signal through the lamp (11) in response to said comparison, characterized in that said ballast (10) further comprises pulse means for sending a current pulse (G2) which is superimposed on said steady state alternating current signal (G1) through the lamp (11) for obtaining said current step.

ABSTRACT:

Method for driving a high pressure gas discharge lamp during its steady state operation, wherein a steady state alternating current signal is sent through the lamp for maintaining a glowing arc in the lamp, comprising the step of comparing the lamp conductivity response to a current step in said alternating current signal with reference parameters; and in response to said comparison at least on of the steps comprising: stopping the current supply to the lamp, generating a signal indicating the end-of-life status of the lamp, changing the steady state current intensity through the lamp, changing the steady state waveform of the alternating current signal through the lamp, generating a signal indicating the lamp type, wherein said current step is obtained by sending a current pulse which is superimposed on said steady state alternating current signal through the lamp.

Fig. 1

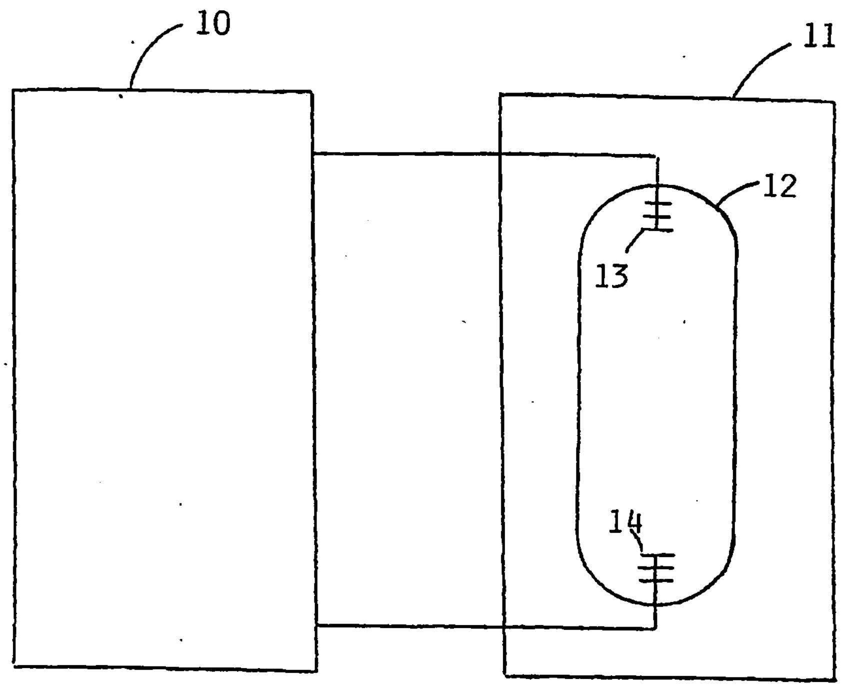


FIG. 1

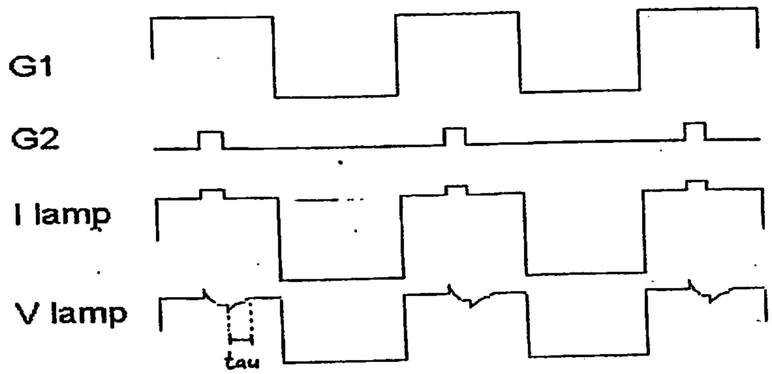
G1
G2
I lamp
V lamp
tau

FIG. 2

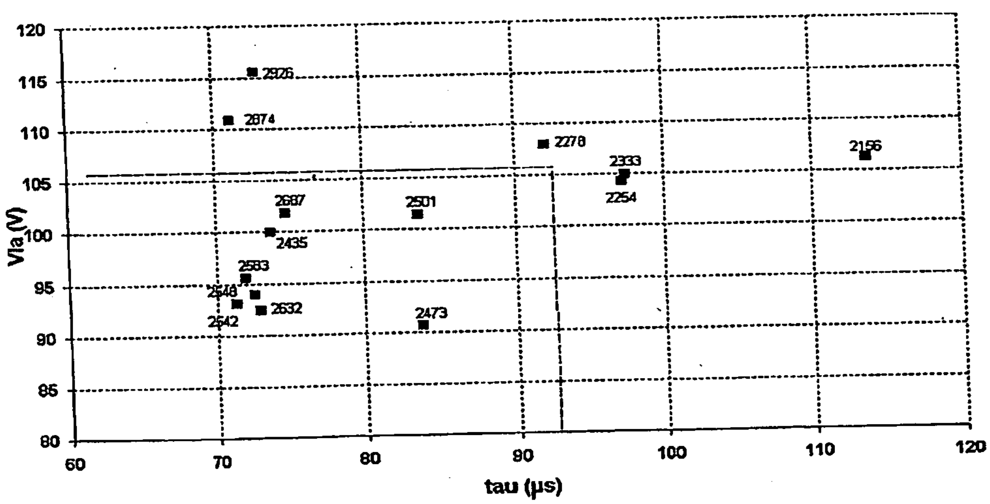
120
115
110
105
100
95
90
85
80
Via (V)
60
70
80
90
100
110
120
tau (µs)
2926
2874
2278
2156
2333
2254
2687
2501
2435
2583
2548
2632
2542
2473

FIG. 3

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